

Some thoughts on di-jet correlation in Au + Au collisions from PHENIX

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Abstract. PHENIX has measured the two particle azimuth correlation in Au + Au at $\sqrt{s} = 200$ GeV. Jet shape and yield at the away side are found to be strongly modified at intermediate and low p_T , and the modifications vary dramatically with p_T and centrality. At high p_T , away side jet peak reappears but the yield is suppressed. We discuss the possible physics pictures leading to these complicated modifications.

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High p_T back-to-back jets are valuable probes for the sQGP [1] created in heavy-ion collisions at RHIC. To date, the interactions of jets with the medium are studied via two particle azimuth correlation method, where particles from one momentum range (triggering particles) are correlated with those from another momentum range (associated particles).

In two particle correlation method, the jet multiplicity is directly related to the number of associated pairs per trigger or per-trigger yield, $Y = \frac{1}{N_{\text{trigs}}} \frac{dN}{d\Delta\phi}$. And the medium modifications of jet/dijet multiplicity are typically quantified by I_{AA} , the ratio of the per-trigger yield in A + A collisions to that in p + p collisions, $I_{AA} = \frac{Y_{AA}}{Y_{pp}}$. Since the single particle yield, thus the number of triggering particles, is suppressed in A + A collisions, the per-trigger yield defined this way contains a trivial R_{AA} factor. We can reach the following simple relation between the per-trigger yield using the high p_T particles (denoted as ‘a’) as triggers and that using low p_T particles (denoted as ‘b’) as triggers:

$$I_{AA}^a R_{AA}^a = I_{AA}^b R_{AA}^b = \frac{\text{JetPairs}_{AA}}{N_{\text{coll}} \times \text{JetPairs}_{pp}} \equiv J_{AA}(p_T^a, p_T^b) \quad (1)$$

Where JetPairs_{AA} and JetPairs_{pp} represent the average number of jet pairs in one A + A collision and one p + p collision, respectively. In addition, we define $J_{AA} = \frac{\text{JetPairs}_{AA}}{N_{\text{coll}} \times \text{JetPairs}_{pp}}$ as the nuclear modification factor of jet pairs. In energy loss picture, surface bias leads to a stronger suppression of away side jet yield than that for single particle yield: $I_{AA} < R_{AA}$ [2], thus $J_{AA} < R_{AA}^a R_{AA}^b$. However, the preliminary results of the di-jet correlation at high p_T from STAR shows that $J_{AA} \approx R_{AA}^a R_{AA}^b$ [3].

The distinctions between the triggering particles and associated particles are arbitrary. I_{AA}^a and I_{AA}^b are not independent of each other as shown in Eq.1. For simplicity, we shall define triggering particles as those from the higher p_T range in following discussions.

Jet correlations at different p_T reflect different aspect of the interaction between jet and the medium. Previous results indicate a seemingly complete disappearance of the away

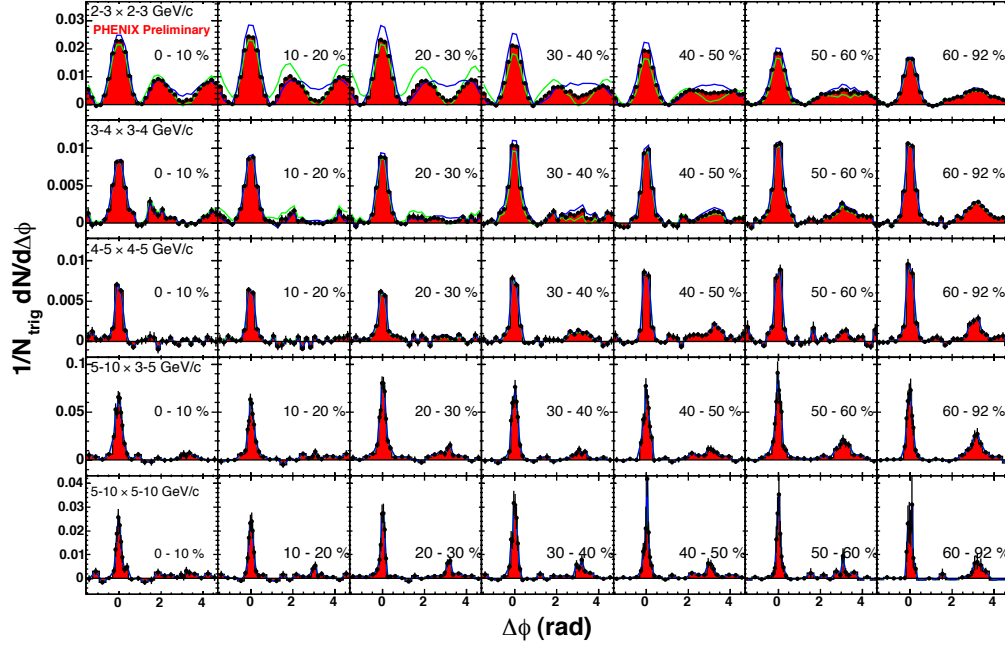


FIGURE 1. Background subtracted per-trigger jet yield in $\Delta\phi$ as function of p_T (vertical) and centrality (horizontal).

side jet signal at moderately high associated p_T (2-4 GeV/c) [4]. At low associated hadron p_T , an enhancement of the away side jet yield [5] and a broadened jet shape [6] were observed. These observations are qualitatively consistent with the energy loss picture, where the high p_T jets are quenched by the medium and their lost energy enhanced the jet multiplicity at low p_T . Recent results from PHENIX [7] and STAR [3] covering broader p_T ranges of the triggering and associated particles provide additional important handles for understanding the detailed interplay between various competing mechanisms. Fig.1 shows a summary plot of the per-trigger yield as function of both p_T (vertical) and centrality (horizontal). Along the vertical direction, we can see how the away side jet evolves from a cone type of structure at intermediate p_T (2-4 GeV/c) to a relatively flat distribution at moderately-high p_T (3-5 GeV/c), to a reappeared jet structure at high p_T (5-10 GeV/c) ¹. The cone structure qualitatively agree with the ‘mach cone’/‘shock wave’ mechanism [8], which represents the collective excitation of the medium by the supersonic partons traversing the medium. The peak structure at the highest p_T bin could be explained by the tangential contribution of the away side jet, when both jets are emitted tangential to the surface. The magnitude of this the peak is reduced compare to the peripheral collisions, reflecting the reduction in the available phase space due to the tangential emission requirement. The tangential contribution must be suppressed even more at lower p_T , in order to describe the relatively flat distribution at

¹ The di-jet modification pattern depends on the p_T of both particles, thus in principle, we should have fixed the triggering particle p_T and vary the associated particle p_T . However, the p_T selections in Fig.1 are somewhat mixed up in favor of better statistical accuracy.

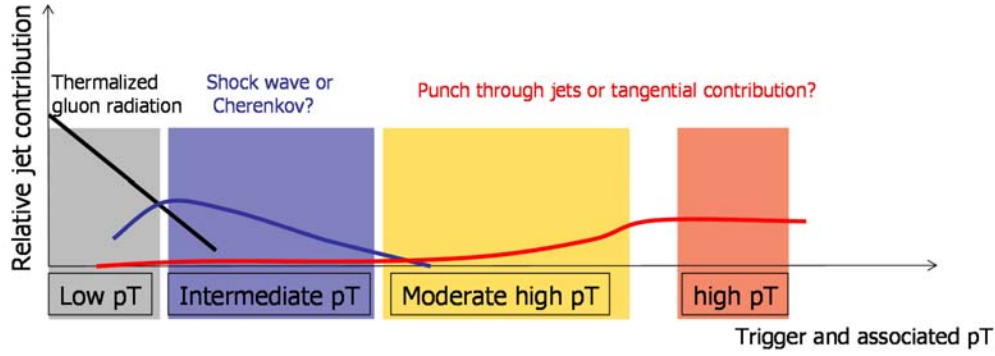


FIGURE 2. A sketch of various contributions to the away side jet yield as function of associated particle and triggering particle p_T . The p_T axis is schematically divided into four different regions. It is chosen such that the $p_{T,\text{trig}} \geq p_{T,\text{assoc}}$ (see Fig.1)).

the away side. Along the horizontal direction, the away side jet modifications in various p_T ranges depend strongly on centrality, consistent with a smooth turn on of various medium effects from peripheral to central collisions. Further detailed discussions can be found in [7].

In Fig.2, we draw a crude picture based on the current results. Different mechanisms play different roles at different p_T . Generally speaking, at low associated particle p_T , the jet yield is dominated by thermalized gluon radiation and this contribution should have a typical exponential thermal spectra and dies out quickly at $p_T > 1 - 2$ GeV/c; at intermediate p_T (1-4 GeV/c), various collective excitation modes of the medium could become important. In the case of Mach cone, its contribution to the yield has an approximate exponential shape; there is a punching-through component, representing the fragmentation from the surviving primary jets. Since the away side jet distribution is very flat at moderately-high p_T (2-5 GeV/c), the punching-through contribution in this and lower p_T bin has to be very small; at high p_T ($> 3 - 5$ GeV/c), tangential contributions could be important and responsible for the clear away side peak structure in central Au + Au collisions.

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